

# Effective Tooth Movement Using Lingual Segmented Arch Mechanics Combined With Miniscrews

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## ABSTRACT

The control of the labiolingual inclination of incisors, or torque, is considered one of the challenging issues in the lingual orthodontics. However, by utilizing lingual/palatal anatomical structures for using miniscrews in conjunction with lever arms, efficient treatment is possible and predictable. This article aims to provide insight into the control of tooth movement using segmented arch mechanics in combination with miniscrews.

Key words: segmented arch mechanics, miniscrews

## INTRODUCTION

Demands for esthetic improvement are one of the major reasons why patients seek orthodontic treatment<sup>1)</sup>, with premolar extraction being a common treatment modality in patients with lip protrusion. Anterior retraction can be performed using continuous straight arch wire, looped arch wire or segmented arch wire<sup>2)</sup>. In the sliding mechanics, the reactivation of the archwire for the space closure is easy and fail-safe, but unpredictable friction may hinder tooth movement. In contrast, looped arch wire deliver force without the friction, but the fabrication and insertion of the looped archwire may be cumbersome and may also cause soft tissue irritation<sup>2)</sup>. In addition to the force delivery, control of the labiolingual inclination, or torque, during retraction has been a major issue in lingual orthodontics, since it has been known that the root movement of lingually inclined incisors may be very difficult. Meanwhile, the segmented arch wire technique, which was introduced by Burstone<sup>3)</sup>, encourages accurate tooth movement via precise positioning of the line of force relative to the center of resistance of the target segment and the moment-to-force ratio at the bracket. Lever arms from the main arch level was suggested a useful tool to increase the moment-to-force ratio and has been adopted in the lingual orthodontics as well as in the labial orthodontics. However, the segmentation of the arch may threaten the fail safety and arch integrity during anterior retraction<sup>2)</sup> (Fig.1).

Lingual orthodontic treatment is favored by many adult patients satisfying the patients' esthetic demands during treatment<sup>4)</sup>. Because of the differences in the anatomy of the labial and lingual side of periodontal structure, specific considerations for biomechanics are applied to the lingual orthodontic treatment. In particular, deep palatal vaults compared to shallow labial/buccal vestibules allow clinicians to extend arbitrary length of the lever

arms to simulate desirable moment-to-force ratio for producing expected type of tooth movement<sup>5</sup>). Regardless of the type of tooth movement, posterior anchorage may be established using the temporary anchorage devices (TADs)<sup>2,6</sup>).

TADs, including the miniscrews, may simplify appliance design in segmented arch mechanics by reinforcing anchorage<sup>7,8</sup>) and also eliminating posterior apparatus for anchorage preparation. They also enable clinicians to apply force in the desired direction or to use space solely for retraction in extraction cases. Therefore, more effective tooth movement with minimal patients' discomfort can be achieved using TADs and segmented arch mechanics in lingual orthodontic treatment.

## **CASE 1**

A 39-year-old woman presented with lip protrusion (Fig.2 A-I). Initial intraoral views exhibit protruded upper and lower incisors and a Class I molar relationship on both sides. Her chin and midlines were deviated slightly to the left and mild gingival recession was evident. There was a 2.0mm arch length discrepancy in the lower arch and her facial profile was convex. Initial cephalometric analysis revealed a Class I skeletal pattern with bi-alveolar protrusion (Fig.2 K,L). In order to relieve lip protrusion, extraction of the four premolars and maximum retraction was deemed necessary. Considering that the patient's U1 to SN angle was within normal range, bodily movement of the upper incisors was planned while controlled tipping was intended for the lower incisors.

### **Appliance design**

To achieve bodily movement or minimal tipping of the upper incisors, the line of force should be situated near the center of the resistance of the incisors<sup>9</sup>). This can be actualized by use of a lever-arm, which extends up to the center of resistance. A recent three-dimensional (3D) finite element analysis demonstrated that long lever arms may deform in the direction of the force, ultimately tipping the incisors lingually<sup>10</sup>). This study also revealed that the extension of lever arms should be as long as 20mm along the palate of the anterior maxilla to assure bodily movement of the anterior segment<sup>10</sup>) (Fig.3). Therefore it is advised to splint the two lever arms with a rigid connecting wire to minimize deflection and to extend the length of the lever arms to the depth of the palate.

The miniscrews can be inserted along the palatal slope or in midpalatal area. To determine the insertion site, it is essential to consider the direction of the force vector with regards to the center of resistance. Force from miniscrews placed in the midpalatal area represents more vertical force compared to miniscrews placed in the palatal slope<sup>6</sup>). In this case, the upper incisors needed to be retracted without intrusion when the exposure of the upper incisors and overbite were taken into consideration. Therefore, two miniscrews (1.8 mm in diameter, 7 mm in length and tapered body, (Orlus serial #18107, Ortholution, Seoul, Korea)) were inserted in the palatal slope to retract the anterior segment bodily and with minimal tipping. As the upper incisors were well aligned, a lever-arm, fabricated with .9mm stainless steel wire with meshpads, was bonded to the anterior teeth and used to retract the anterior segment prior to alignment (Fig.4 A,B).

### **Miniscrews as indirect anchorage**

Maximum anterior retraction was needed in the lower arch as well as in the maxillary arch. For the lower dentition, miniscrews were inserted in the buccal alveolus between the second premolar and first molar to anchor the posterior teeth indirectly (Fig.4 C-G). Although a lingual lever arm could be placed, a longer lever arm as in the maxilla cannot easily be used in patients with shallow lingual vestibules due to limited space and

the tongue, so it is advisable to insert miniscrews in the buccal alveolus when maximum anchorage is needed.

### Treatment summary

After premolar extraction, the upper anterior teeth were retracted with a palatal lever arm prior to alignment while the lower dentition underwent alignment and retraction (Fig.4 A,B). In both arches, maximum anchorage was assured with the use of miniscrews, inserted according to precisely designed force vectors. When the upper extraction spaces were almost closed, upper lingual braces were bonded to align and finish the case simultaneously (Fig.4 H,I).

### Assessment

Lip protrusion was relieved and the nasolabial angle increased (Fig.5 A-D). The roots were parallel and the alveolar bone level was well maintained, but slight blunting of anterior root apices was observed (Fig.5 J). In the cephalometric assessment, the upper and the lower incisors were retracted via bodily movement (U1 angle reduced only 5°) and controlled tipping, respectively, while the positions of the upper and the lower molars were well maintained (Fig.5 K-M). After one and a half years of retention, the patient showed a good occlusion and the posterior bite settled (Fig.6).

## CASE 2

A 26-year-old woman presented with a chief complaint of lip protrusion (Fig.7 A-L). Initial cephalometric analysis showed a skeletal Class I pattern with slight lip protrusion. The maxilla was canted down towards the right. The amount of crowding was minimal and the patient had a prominent chin. The upper and lower dental midlines were coincident, but commonly deviated 2mm to the left of the facial midline. She had a mild Class II molar relationship on the right and a Class I molar relationship on the left. To relieve lip protrusion and correct the midline deviation, extraction of the upper and lower right premolars was planned due to the patient's asymmetric molar relationships and her prominent chin in an effort to avoid excessive lip retraction.

### Appliance design and Miniscrew Insertion

As the anterior teeth were well aligned, retraction of the upper anterior segment prior to alignment as one unit was planned using a bonded lever arm. The lever arm was fabricated with meshpads and .09 mm stainless steel, and hooks were soldered at varying heights (Fig.8). This allowed for control of the anterior segment according to force design without jiggling. The direction of force application can easily be altered with hooks and miniscrews at different sites.

A miniscrew (1.8 mm in diameter, 7 mm in length and tapered body) (Orlus serial #18107, Ortholution, Seoul, Korea) was inserted into the palatal slope between the right first and second molars (Fig.8).

### Treatment Summary

To intrusively retract the upper incisors first, a force was driven from the hook at the deepest portion of palate. When the overbite became shallow and the axis of the incisors appeared flared (Fig.9 A,B), the direction of force application was altered to go through the center of resistance in order to achieve bodily movement (Fig.10 A). Additionally, miniscrews were inserted at the midpalate and the buccal alveolus to correct maxillary canting (Fig.10). At regular check-ups, the force direction was simply changed according to the occlusion without any

additional devices. When the extraction spaces were almost closed, upper lingual brackets were bonded for alignment and detailing (Fig.11 A-E).

The lower dentition was conventionally aligned and retracted using continuous arch mechanics. Clear buttons were bonded to achieve seating of the bite with elastics (Fig.11 A-E).

### **Assessment**

In the extra oral photographs, it is evident that the dental midlines were coincident to the facial midline and the maxillary cant was corrected. Lip fullness was also relieved (Fig.12 A-D). The roots were parallel and the alveolar bone level seemed slightly lower in the lower anterior region (Fig.12 J). The upper and the lower incisors were retracted via controlled tipping, resulting in a decrease of the axes of 10° and 5.5°, respectively (Fig.12 K-M).

## **CONCLUSION**

Segmented arch mechanics using TADs is useful in lingual orthodontic treatment because various force applications are possible with anatomical advantages. A deep palatal vault is advantageous for a long lever arm, which makes it possible for the force to be delivered through or above the center of resistance. The palate also offers relatively safe and abundant insertion sites for miniscrews. By varying implant sites and lever arm design, it is possible to change force vectors and therefore control tooth movement efficiently. The amount of time that the brackets are bonded is also minimized, thus delivering simple and esthetic orthodontic treatment to patients.

## **FIGURE LEGENDS**

### **Figure 1.**

Different mechanics of space closure A. Sliding mechanics B. Looped mechanics C. Segmented arch wire mechanics—Park et al. JCO 2000;34:601-5.

### **Figure 2.**

Pre-treatment diagnostic records of case 1. (A-D) Extraoral photographs. (E-I) Intraoral photographs. (J) Panoramic radiograph. (K) Lateral cephalometric radiograph. (L) Cephalometric tracing.

### **Figure 3.**

Lever arm design in 3D finite element model. (A) Lateral View. (B) Occlusal view with application of forces from the MIs direct to the lingual archwire. (C) Occlusal view with application of forces from the MIs to hooks attached to the lingual archwire.—Kim et al. KJO 2011;41(5):324-336.

### **Figure 4.**

Progress occlusal photographs during retraction; Retraction of the upper anterior segments with bonded lever arm (A) and alignment of lower dentition (B).

### **Figure 5.**

Post-treatment diagnostic records of case 1.(A-D) Extraoral photographs. (E-I) Intraoral photographs. (J) Panoramic radiograph. (K) Lateral cephalometric radiograph. (L) Cephalometric tracing. (M) Cephalometric superimposition of the tracing before (blue line) and after (red line) the treatment.

### **Figure 6.**

Follow-up records of case 1, one and a half year of retention.

### **Figure 7.**

Pre-treatment diagnostic records of case 2. (A-D) Extraoral photographs. (E-I) Intraoral photographs. (J) Panoramic radiograph. (K) Lateral cephalometric radiograph. (L) Cephalometric tracing.

**Figure 8.**

Progress occlusal photographs during retraction of the anterior segments with upper bonded lever arm (A) and conventional sliding mechanics (B).

**Figure 9.**

Progress lateral cephalometric tracing (A) and superimposition (B) before (blue line) and during (yellow line) the treatment.

**Figure 10.**

Progress photographs during retraction of the anterior segments changing the direction of force and canting correction (A,B,C,D,E).

**Figure 11.**

Progress photographs of bonding upper brackets and finishing after 17 months of retraction (A,B,C,D,E).

**Figure 12.**

Post-treatment diagnostic records of case 2. (A-D) Extraoral photographs. (E-I) Intraoral photographs. (J) Panoramic radiograph. (K) Lateral cephalometric radiograph. (L) Cephalometric tracing. (M) Cephalometric superimposition of the tracing before (blue line) and after (red line) the treatment.

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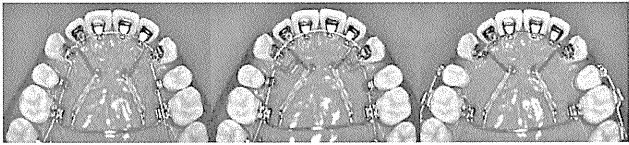


Fig.1 A,B,C

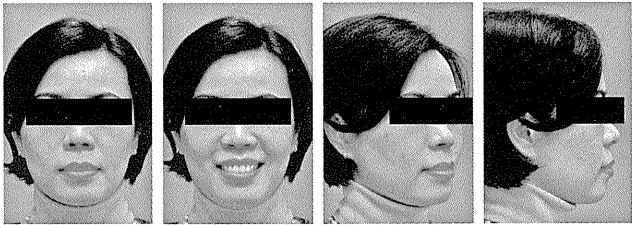


Fig.2 A,B,C,D



Fig.2 E,F,G



Fig.2 H,I

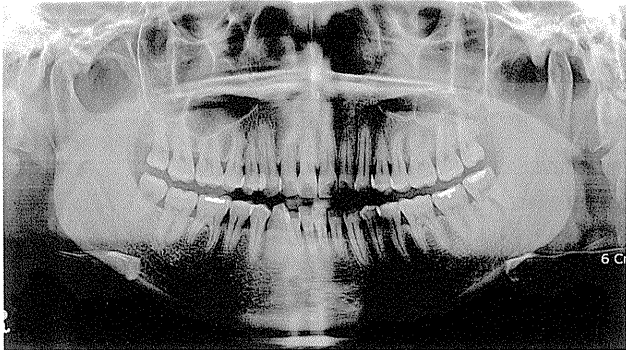


Fig.2 J

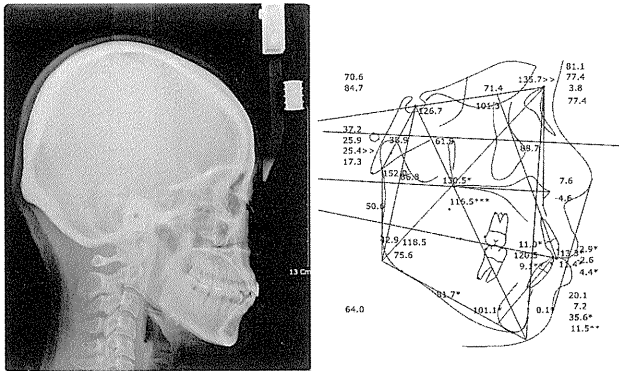


Fig.2 K,L



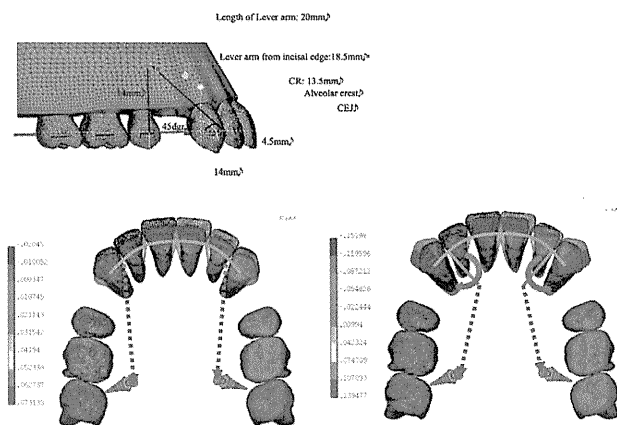


Fig.3 A,B,C

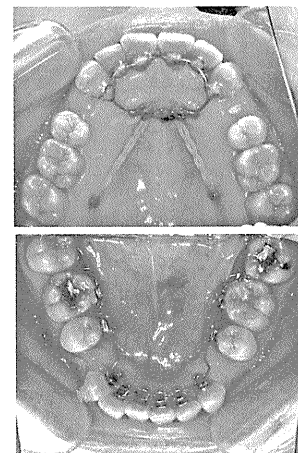


Fig.4 A,B

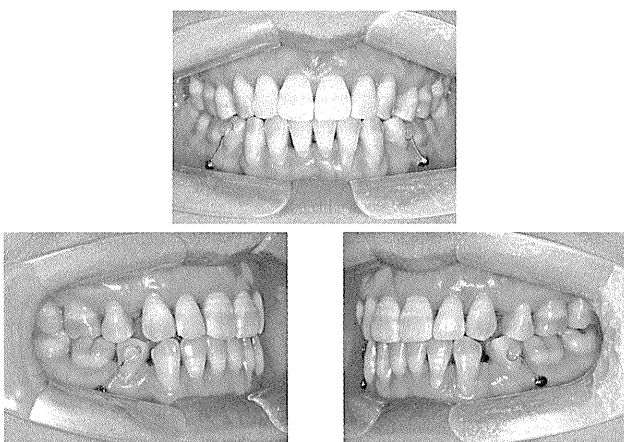


Fig.4 C,D,E

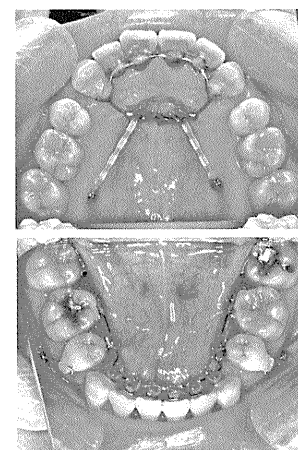


Fig.4 F,G

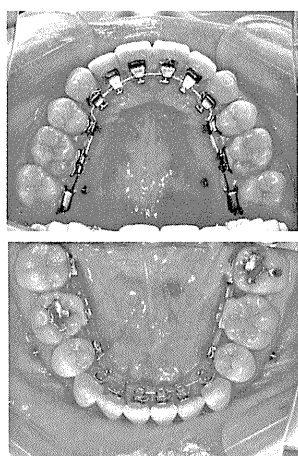


Fig.4 H,I

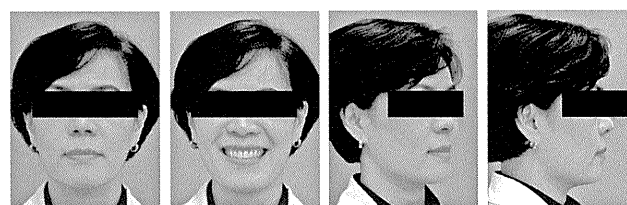
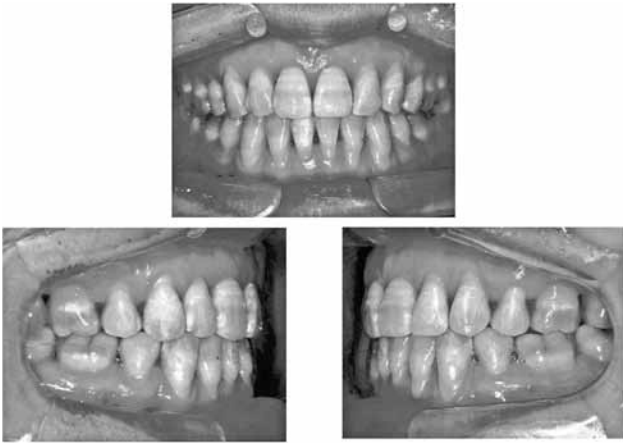
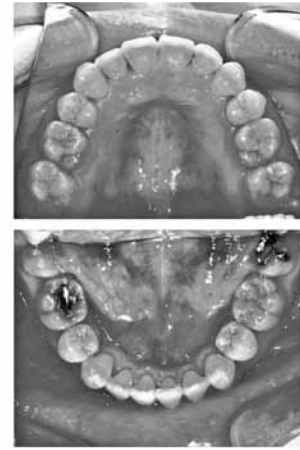


Fig.5 A,B,C,D



**Fig.5 E,F,G**



**Fig.5 H,I**



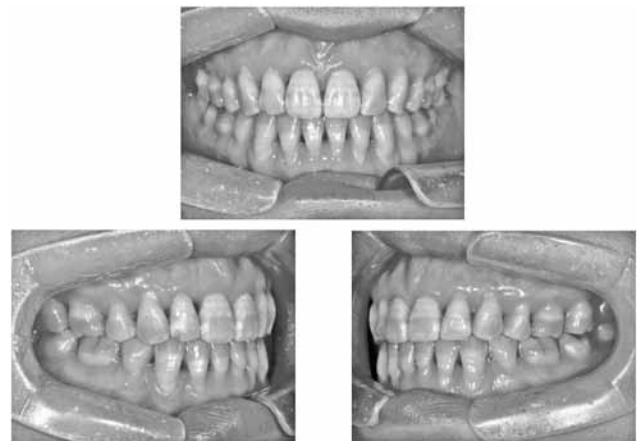
**Fig.5 J**



**Fig.5 K,L**



**Fig.5 M**



**Fig.6 A,B,C**



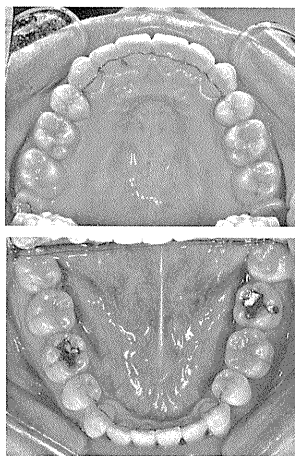


Fig.6 D,E

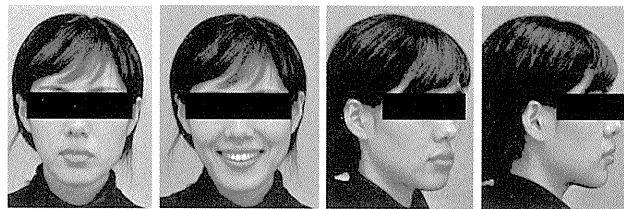


Fig.7 A,B,C,D

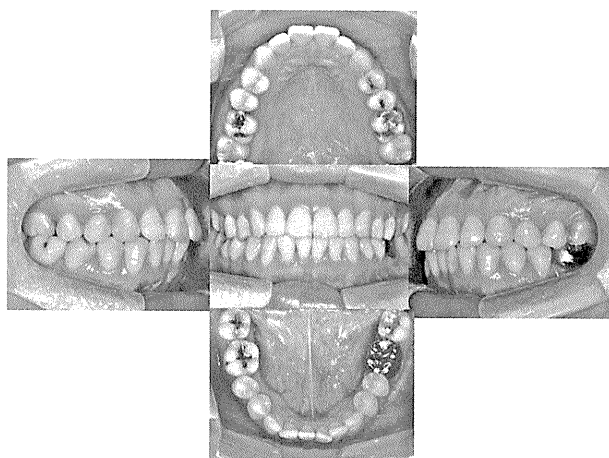


Fig.7 E,F,G,H,I

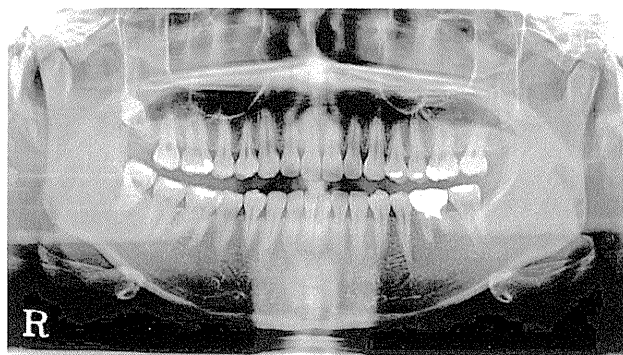


Fig.7 J

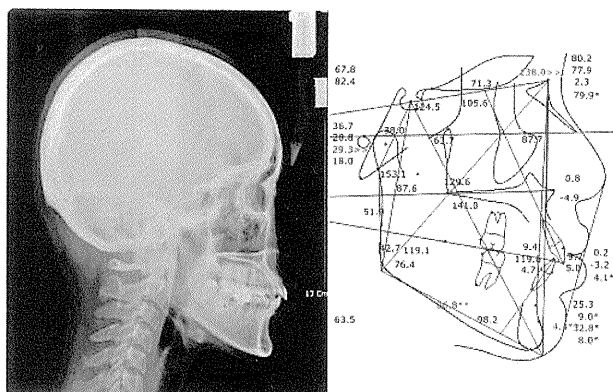


Fig.7 K,L

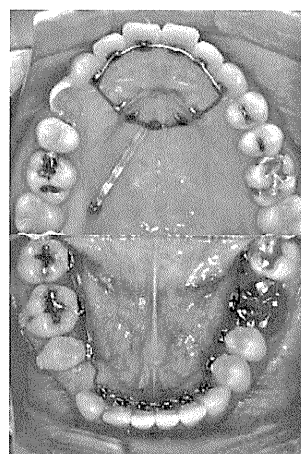


Fig.8 A,B

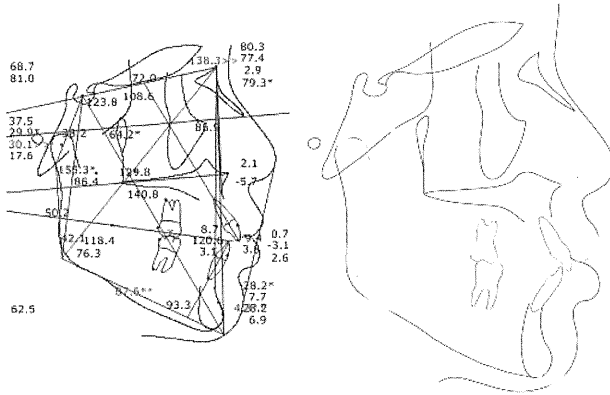


Fig.9 A,B



Fig.10 A,B,C,D,E

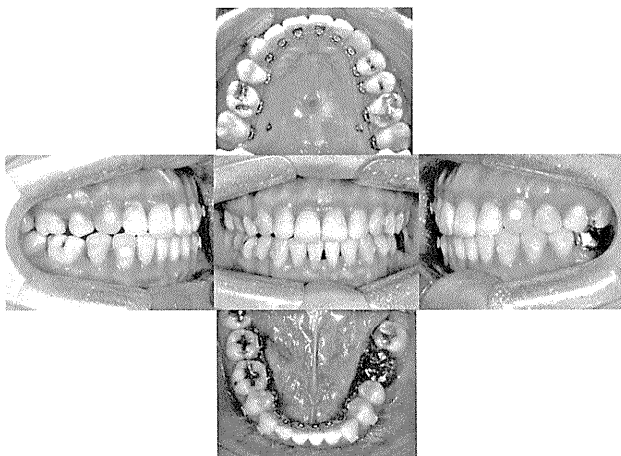


Fig.11 A,B,C,D,E



Fig.12 A,B,C,D

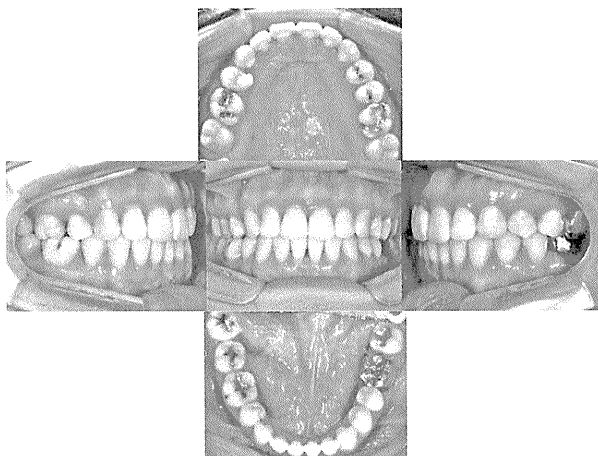


Fig.12 E,F,G,H,I

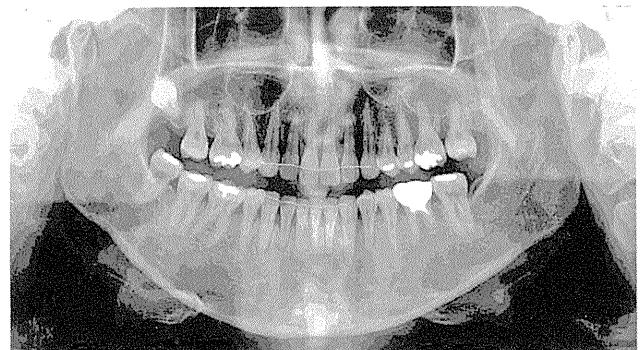
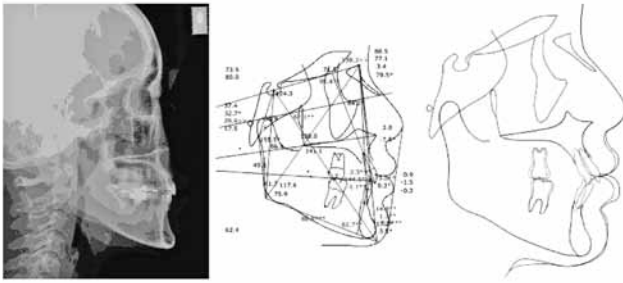


Fig.12 J



**Fig.12 K,L,M**